Data Normalization

Chapter 4

Data Normalization

- **One of the most challenging and perennial problems confronting the cost analyst is the identification and normalization of cost data.**
- **The adjustment of actual cost to a uniform basis has two objectives:**

  -- Reduces the dispersion of the data points – "Consistency"

  -- Expands the number of comparable data points – "Homogeneity"

- **Also, since historic cost data involves the purchasing of goods and services in different time periods, we need to know how to compare the dollar cost of goods and services in one period with the dollar cost of comparable items in another period.**

Data Normalization

- **Normalization provides consistent cost data by neutralizing the impacts of external influences**
- **The three broad Normalization topics are:**
  - **Content**
  - **Quantity**
  - **Inflation**
- **Normalization efforts involve adjustments for:**
  - **Technology changes**
  - **Data collection differences**
  - **Production methodology enhancements**
  - **Design Improvements**
  - **Inflation and deflation**

Normalization for Content

- **Is there an “apples-to-apples” comparison?**
- **This is largely a problem of mapping different data sets**

My WBS	**Historical Dat**
Air Vehicle	Air Vehicle
Airframe	Airframe
Powerplant	Propulsion
Communications	Comm / Nav
Navigation	Avionics
ECM	
Auto Flight Control	
Mission Subsystem	SE
SE/PM	PM
Data	Data

Normalization for Quantity

- **How does Quantity affect cost? (Think Costco)**
- **Does Cost Improvement take place?**
- **At what rate does cost improve?**
- **Normalization for Quantity ensures we are comparing the same type of cost, whether it be Total, Lot, or Unit level**
- **When we collect production cost data, we usually get it in terms of "Total Cost for X Units", or lot costs for units "X through Y".**
- **Basic Learning Curve theory says:**
  - **As the quantity produced doubles, the unit cost, or cumulative average cost, decreases at a constant rate**
  - **This decrease is called the "rate of learning"**

Normalization for Quantity

- **Learning Curve Basics:**

$Y_X = AX^b$

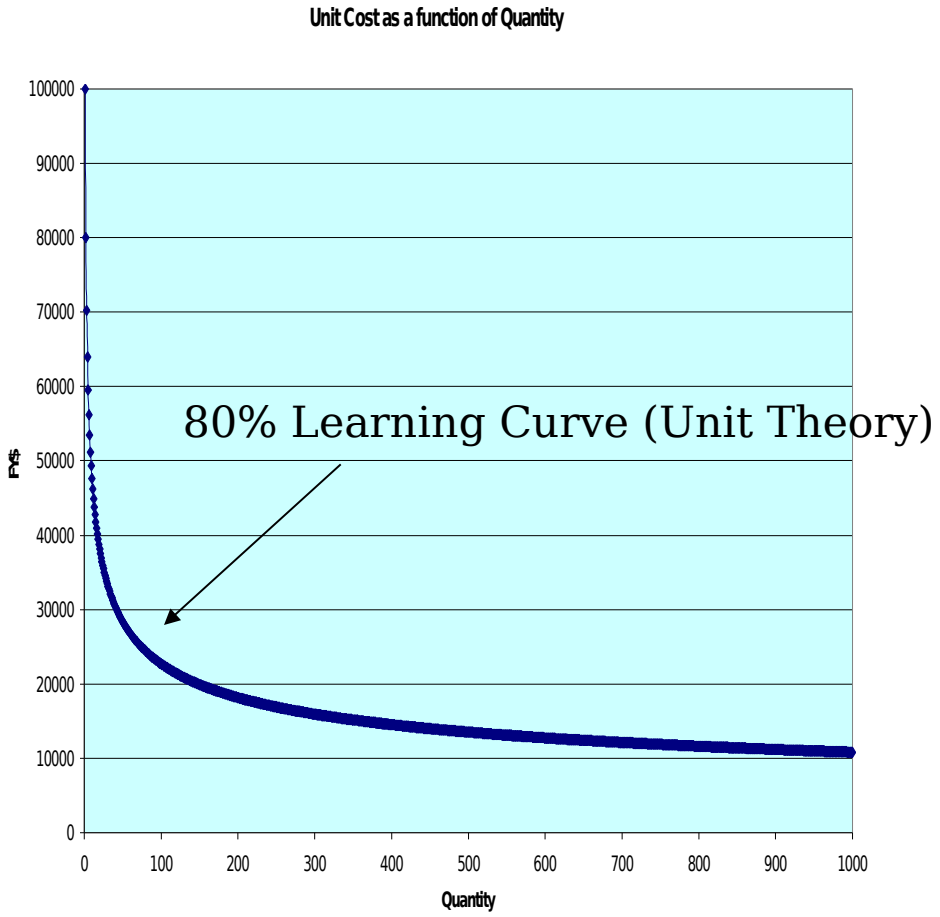
where

Y_X = The cost of the Xth unit

A = First Unit Cost (T1)

X = The Unit in question

b = Slope coefficient, $b = \ln(\text{slope})/\ln(2)$



Normalization for Quantity

- **When we normalize for quantity, we try to find an "anchor point" to use as a data point for developing CERs.**

- **An example would be to use T1, or T100, something that is at the same point in the production process. (See Example in class of "Good and Bad Data Sets")**

Normalization for Inflation

- **We do most of our normalization to account for inflation**
- **If System X costs $1M today, how much will that same system cost five years from now?**
- **A reflection of the fact that a dollar spent today buys more than it will in the future but buys less than it did in the past**
  - **the effects of inflation over time**
- **Of all the topics discussed in cost analysis, none will be encountered more frequently than inflation**

Inflation

- **“The consistent rise in the price of a given market basket of goods produced by an economy”**
  - **A rise in the general price level of goods and services produced in an economy**
  - **Measured by the rate of rise of some general product-price index in percent per year – examples?**
- **Many different measures of inflation are required because prices do not rise evenly.**
- **Similarly, DoD uses different measures, as well.**

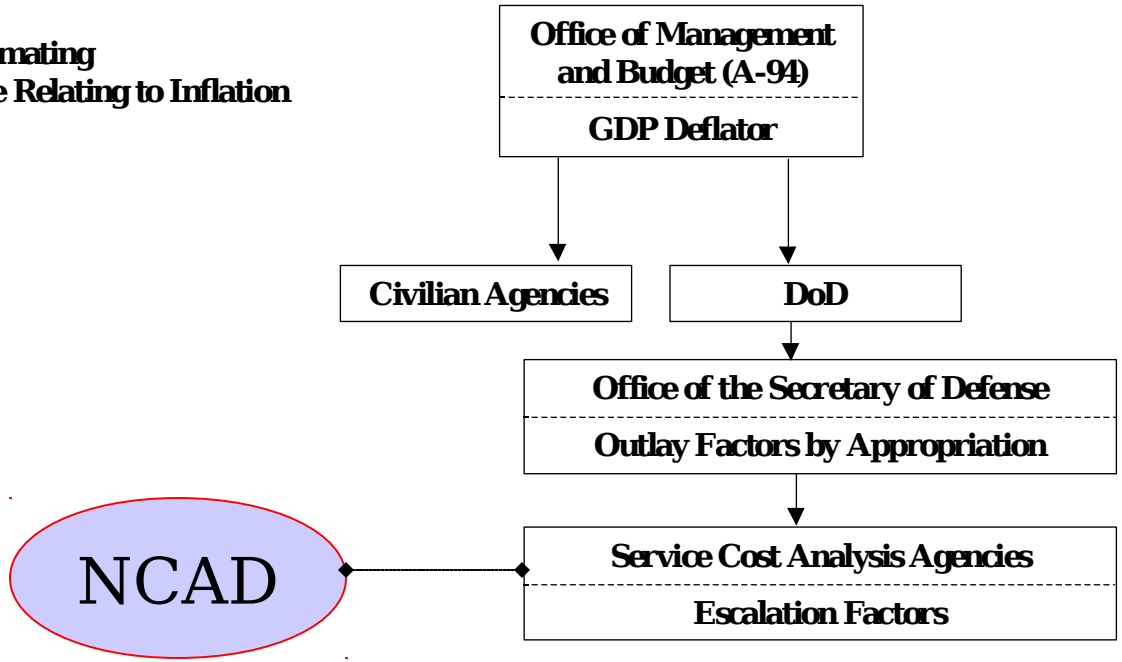
How Inflation and Escalation Guidance is Developed

Financial Concepts Overview…Inflation, Process

Measurements of Inflation

Bureau of Economic Analysis	Bureau of Labor Statistics
Gross Domestic Product (GDP) Deflator	Consumer Price Index

Cost Estimating Guidance Relating to Inflation



Inflation Indices

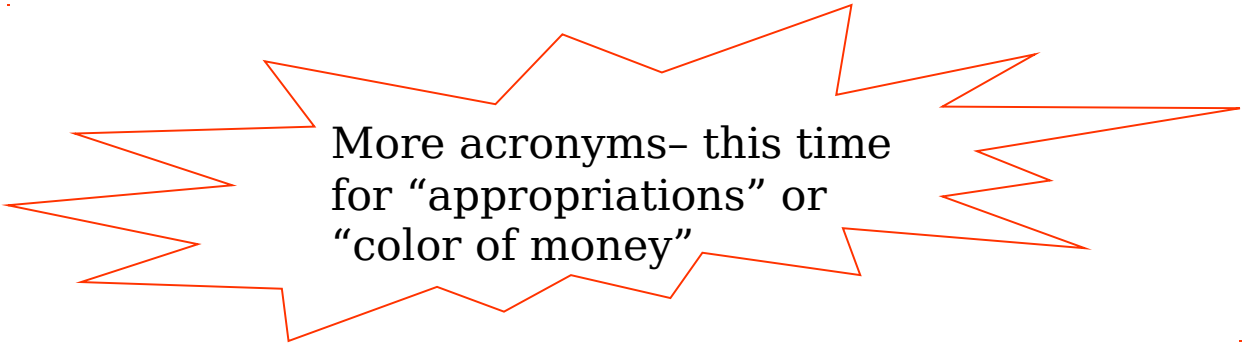
- **Index: simply a ratio of one quantity to another**
  - **Expresses a given quantity in terms of its relative value compared to a base quantity**
- **Inflation index is an index designed to measure price changes over time**
  - **A ratio of one price or combination of prices to the price of the same item or items in a different period of time**
- **Base period must be selected before an inflation index can be developed**
  - **A given year, arbitrarily chosen**
  - **Base year market basket is assigned a value of one**
    - » **price changes to the market basket are then always compared to the base year**
    - » **base period for a defense system is often the fiscal year in which the program was initially funded**

DoD Inflation Indices

- **Indices are developed for a particular activity or type of procurement**
  - **Rate of inflation differs for each market basket**
    - » **APN, WPN, OPN, SCN, OMN, MPN, etc.**

- **Indices are used to convert to constant year dollars (CY$), base year dollars (BY$), then year dollars (TY$)**

- **http://www.ncca.navy.mil/services/inflation.cfm**



http://www.defenselink.mil/comptroller/defbudget/fy1998/inflatio.pdf

FY 1999 PRESIDENT'S BUDGET
PRICE ESCALATION INDICES
(Annual Rates in Percentages)

OUTLAYS

Fiscal Year	Procurement	RDTE	Mil Con FH Const	O&M (Excl Fuel)	O&M Fuel	Mil 1/ Pers Non-Pay	CPI-U Medical
1998	1.4	1.4	1.4	1.4	19.7	1.4	3.4
1999	1.5	1.5	1.5	1.5	-8.8	1.5	3.9
2000	1.6	1.6	1.6	1.6	2.1	1.6	3.9
2001	1.7	1.7	1.7	1.7	2.1	1.7	3.9
2002	1.7	1.7	1.7	1.7	2.1	1.7	3.9
2003	1.7	1.7	1.7	1.7	2.1	1.7	3.9
2004 3/	2.2	2.2	2.2	2.2	2.1	2.2	3.9

BUDGET AUTHORITY 2/

1998	1.5	1.5	1.5	1.5	19.7	1.4	3.4
1999	1.6	1.6	1.6	1.6	-8.8	1.5	3.9
2000	1.7	1.7	1.7	1.6	2.1	1.6	3.9
2001	1.9	1.7	1.8	1.8	2.1	1.7	3.9
2002	1.9	1.8	1.8	1.8	2.1	1.7	3.9
2003	2.0	2.0	2.1	1.9	2.1	1.7	3.9
2004 3/	2.2	2.2	2.2	2.2	2.1	2.2	3.9

PAY RAISE ASSUMPTIONS 4/

	ECI	Military	Civilian
1998	3.3	2.8	2.8
1999	3.6	3.1	3.1
2000	3.5	3.0	3.0
2001	3.5	3.0	3.0
2002	3.5	3.0	3.0
2003	3.5	3.0	3.0
2004 3/	3.5	3.0	3.0

1/ Not to be used to inflate accounts fixed by statute.

2/ These are composite rates at the title level. Inflation rates for specific accounts are a function of the spend out profiles and will vary within each title.

3/ These rates are to be used for all years beyond 2004.

4/ All pay raises effective January 1.

Constant Year Dollars (CY$)

- **CY$ reflect the purchasing power or value of the dollar in the specified constant fiscal year**
  - **$ are assumed to be totally expended in the specified FY**

    “Total depot maintenance for the Armored Vehicle Launched Bridge was $4.77M, CY93$”

    - **Does not imply that $4.77M was paid to the contractor in FY93**
    - **Total depot maintenance would have been $4.77M *if* all expenditures has occurred in FY93**

- **If you hear that a program costs, say, $300 M over 10 years, it is in Constant Year dollars.**

Base Year Dollars (BY$)

- **BY$ are a subset of CY$**
  - **Base year formally defined as the fiscal year in which the program was initially funded**
  - **Enables a decision maker to distinguish between a change in the cost of a program and a change in the purchasing power of the dollar**

Year of Report	Estimate	
1992	$450M CY92$	$450M BY92$
1994	$467M CY94$	$450M BY92$
1997	$501M CY97$	$476M BY92$

Then Year Dollars (TY$)

- **In reality, do all expenditures for a program occur within one year?**
- **TY$ represent the amount of money needed when the expenditures for goods and services are made**
  - **Reflect the actual flow of expenditures during an acquisition program**
  - **Include an expenditure profile**

Suppose a program office intends to buy 30 SAMs in FY98. They take 3 years to build. Is that money requested in FY98?

Raw (Compound) Inflation Index

- **An index developed to reflect the compounding of inflation rates from a base year**
  - **BY's raw index (RI) is by definition 1.000**
    - » **if inflation rate (r) for BY+1 = 3.9%, compound index would be 1.039 = (1.000)(1+0.039)**
    - » **general formula:**

$$\text{RI for BY+i} = (\text{BY})(1+r_{BY+1}) \ldots (1+r_{BY+i})$$

$$\text{RI for BY}_{-i} = (\text{BY})/(1+r_{BY}) \ldots (1+r_{BY-i+1})$$

Year	Inflation Rate	Raw Index
1991	3.5%	0.934
1992	2.9%	0.961
1993	4.1%	1.000
1994	5.2%	1.052
1995	4.5%	1.099

Outlay Profile

- **The rate at which a given year's Total Obligation Authority (TOA) was expended or is expected to be expended**
  - **Calculated by OSD based on TY$**

FY	Development
1995	53.2/ 34.5/ 8.8/ 3.5

  - **Out of the total money appropriated for development in FY95, 53.2% was expended in FY95, 34.5% in FY96, 8.8% in FY97, and 3.5% in FY98**

Composite (Weighted) Inflation Index

- **Combines the compound inflation index with the outlay profile. Similar concept to compound interest**

- **Used to make transformations between TY$ and CY$**

  - **30 SAMs are to be procured in FY96 for delivery in FY98. The estimated cost for these missiles is $35M (CY96$). Will $35M cover the bill?**

Weighted (Composite) Inflation Index

(1)	(2)	(3)	(4)	(5)	(6)	(7)
FY	Inflation Rate	Raw Index	Outlay Profile(%)	Expenditure Profile(%)	CY Outlay Profile(%)	Weighted Index
94	2.5%	1.000	51.8	51.8	52.8	0.528
95	2.8%	1.028	34.5	33.5	34.2	0.351
96	2.9%	1.058	9.0	8.5	8.6	0.091
97	3.0%	1.090	1.2	1.1	1.1	0.012
98	3.0%	1.122	3.6	3.2	3.3	0.037
			100.0	98.1	100.0	1.020

$35M * 1.02 = $35.73M

- Compute raw index
- Remove inflation from outlay profile { col(5) = col(4) ÷ col(3) }
- Normalize col(5) to sum to 1.0 { col(6) = col(%) ÷ .981 }
- Weight CY outlay profile by raw index and add
  - Weighted index = Σ col(3) * col(6)

Inflation Adjustments

- **Costs are adjusted to reflect the effects of inflation for three reasons:**
  - **To adjust historical costs to the same standard**
    - » **CY$ or BY$**
  - **To submit budget requests to Congress (TY$)**
  - **To calculate “escalation” for contractors – adjusts reasonable profits if inflation is less than expected**

- **Only costs that are computed using the same base year (or constant year) are comparable.**

- **Basic calculations**
  - **CY$ to CY$**
  - **CY$ to TY$, TY$ to CY$**
  - **TY$ to TY$**

CYXX$ ⇒ CYYY$

- **1. Locate page for applicable appropriation with base year BYXX.**
- **2. On that page, locate the CYYY raw inflation index in column headed “RAW INDEX.”**
- **3. Multiply the dollar amount by this index.**

OR

- **1. Locate page for applicable appropriation with base year BYYY.**
- **2. On that page, locate the CYXX raw inflation index in column headed “RAW INDEX.”**
- **3. Divide the dollar amount by this index.**

OR

- **1. Locate page for applicable appropriation with any base year.**
- **2. On that page, locate the raw inflation index for year XX in column headed “RAW INDEX.”**
- **3. Divide the dollar amount by this index.**
- **4. On the same page, locate the raw inflation index for year YY in the same column.**
- **5. Multiply the result of (3) by this index.**

CYXX$ ⇒ CYYY$

- **Example: Normalize helicopter R&D costs to CY94$ and CY98$:**

Program	R&D Costs		R&D Costs (CY94$)	R&D Costs (CY98$)
Cobra	512M	CY88$		
Apache	452M	CY94$		
Chinook	756M	CY92$		
Kiowa	245M	CY85$		

CYXX$ ⇒ TYYY$

- **1. Locate page for applicable appropriation with base year BYXX.**
- **2. On that page, locate the weighted inflation index for year YY in column headed “WEIGHTED INDEX.”**
- **3. Multiply the dollar amount by this index.**

OR

- **1. Locate page for applicable appropriation with any base year.**
- **2. On that page, locate the raw inflation index for year XX in column headed “RAW INDEX.”**
- **3. Divide the dollar amount by this index.**
- **4. On the same page, locate the weighted inflation index for year YY in the column headed “WEIGHTED INDEX.”**
- **5. Multiply the result of (3) by this index.**

TYXX$ ⇒ CYYY$

- **1. Locate page for applicable appropriation with base year BYYY.**
- **2. On that page, locate the weighted inflation index for year XX in column headed “WEIGHTED INDEX.”**
- **3. Divide the dollar amount by this index.**

OR

- **1. Locate page for applicable appropriation with any base year.**
- **2. On that page, locate the weighted inflation index for year XX in column headed “WEIGHTED INDEX.”**
- **3. Divide the dollar amount by this index.**
- **4. On the same page, locate the raw inflation index for year YY in the column headed “RAW INDEX.”**
- **5. Multiply the result of (3) by this index.**

TYXX$ ⇒ TYYY$

- 1. Locate page for applicable appropriation with base year BYXX.
- 2. On that page, locate the budget year multiplier for year YY in column headed “BUDGET YEAR MULTIPLIER.”
- 3. Multiply the dollar amount by this index.

OR

- 1. Locate page for applicable appropriation with any base year.
- 2. On that page, locate the budget year multiplier for year XX in column headed “BUDGET YEAR MULTIPLIER.”
- 3. Divide the dollar amount by this index.
- 4. On the same page, locate the budget year multiplier for year YY in the same column.
- 5. Multiply the result of (3) by this index.

Inflation Conversion Problems

- **Perform the following conversions using the WPN Inflation Indices for BY98:**

45M CY85$ to CY93$

32M CY91$ to CY95$

500K CY98$ to CY93$

2.1M CY90$ to CY97$

630K TY99$ to CY$94

523M CY93$ to TY$01

2.4M TY$92 to TY$98

Other Considerations

- **Spreading a point estimate, expressed in CY$, over a program's period of performance**
- **Normalizing cost data which was contracted out over several years**
- **Adjusting a program's funding profile, expressed in TY$, for program delays, stretchouts, compressions**

Spreading a Point Estimate

- **The estimated production cost for the next generation tracked vehicle is 560M CY92$. Based on the buy schedule, the dollars were spread as follows:**

Next Generation Tracked Vehicle
(CY92$M)

FY96	FY9Y	FY98	FY98	TOTAL
80	175	205	100	560

  - **$560M will not cover the program requirements since inflation has not been accounted for. To correct, express the CY92$ in TY$. * Use WPN Indices ***

Spreading a Point Estimate

	FY96	FY97	FY98	FY99
CY92$	80	175	205	100
Index	0.8793	0.8793	0.8793	0.8793
CY98$	90.98	199.02	233.14	113.73
Indice	0.9959	1.0182	1.0408	1.0639
TY $$	90.61	202.64	242.65	120.99
			Total =	656.89

Normalization of Historical Costs

- **The following data was gathered on a satellite program. The program, which purchased two satellites, went from 1981 through 1986. Normalize the $ to CY86.**
  - **Contracted amount will be expended over several years**
    - » **definition for TY$ applies**
  - **Historical expenditures will already have been normalized using compound indices**
    - » **definition for CY$ applies**

XYZ Satellite Program ($M)

	FY81	FY82	FY83	FY84	FY85	FY86	TOTAL
Contracted Amount	275	250	0	0	0	0	525
Expenditures	29	91	186	153	58	8	525

Normalization of Historical Costs

Contracted Amount	275	250	0	0	0	0	525
Expenditures	29	91	186	153	58	8	525
BY83 Indices							
Raw	0.837	0.917	1.000	1.080	1.117	1.148	
Weighted	0.968	1.036	1.097	1.144	1.171	1.215	
BY86 Indices (Rebased)							
Raw	0.729	0.799	0.871	0.941	0.973	1.000	
Weighted	0.843	0.902	0.956	0.997	1.020	1.058	
Contracted Amount (CY86$M)	326	277.0					603.2
Expenditures (CY86$M)	39.8	113.9	213.5	162.6	59.6	8.0	597.5

Normalization for Programmatic Adjustment

- **The estimated cost to develop the shoulder mounted artillery system (SMAS) is 175M TY$ based on the following funding profile:**

SMAS RDT&E Program (TY$)

FY95	FY96	FY97	FY98	Total
25.0	45.0	55.0	50.0	175.0

  - **Due to a funding constraint, the Program Manager can not begin the RDT&E effort until FY96. In addition the program, must be stretched out one year by slipping 30% of the effort for each year into the following year.**

    What is the revised RDT&E cost?

Normalization for Programmatic Adjustment

- **When accounting for schedule changes, always convert to CY$ first**

SMAS RDT&E Program

	FY95	FY96	FY97	FY98	FY99	FY00	Total
TY$M	25.0	45.0	55.0	50.0	0.0	0.0	175.0
Index #s	1.0418	1.0652	1.0886	1.1126			
CY94$M	24.0	42.2	50.5	44.9	0.0	0.0	161.7
			CY94$M				
One yr slip		24.0	42.2	50.5	44.9	0.0	
30% slip		16.8	36.8	48.0	46.6	13.5	161.7
Index #s		1.0652	1.0886	1.1126	1.1371	1.1621	
TY$M		17.9	40.0	53.4	53.0	15.7	180.0